

Icarus

INTERNATIONAL JOURNAL OF SOLAR
SYSTEM STUDIES

Volume 49 • 1982

EDITOR: *Joseph A. Burns*

*Space Science Building
Cornell University
Ithaca, New York 14853*



ACADEMIC PRESS

A Subsidiary of Harcourt Brace Jovanovich Publishers

New York London

Paris San Diego San Francisco São Paulo Sydney Tokyo Toronto

Copyright © 1982 by Academic Press, Inc.

ALL RIGHTS RESERVED

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the copyright owner.

The appearance of the code at the bottom of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal or internal use, or for the personal or internal use of specific clients. This consent is given on the condition, however, that the copier pay the stated per copy fee through the Copyright Clearance Center, Inc. (21 Congress Street, Salem, Massachusetts 01970), for copying beyond that permitted by Sections 107 or 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale. Copy fees for pre-1982 articles are the same as those shown for current articles.

MADE IN THE UNITED STATES OF AMERICA

CONTENTS OF VOLUME 49

NUMBER 1, JANUARY 1982

A. SANCHEZ LAVEGA. Motions in Saturn's Atmosphere: Observations before Voyager Encounters	1
FRANCISCO VALDES, WILLIAM J. WELCH, AND DEBORAH HABER. The Jovian Ammonia Abundance from Interferometric Observations of Limb Darkening at 3.4 mm.....	17
TH. ENCRENAZ AND M. COMBES. On the D/C Ratio in the Atmosphere of Uranus	27
D. DEMING, F. ESPENAK, D. JENNINGS, T. KOSTIUK, AND M. MUMMA. Evidence for High-Altitude Haze Thickening on the Dark Side of Venus from 10-Micron Heterodyne Spectroscopy of CO ₂	35
A. SEIFF AND DONN B. KIRK. Structure of the Venus Mesosphere and Lower Thermosphere from Measurements during Entry of the Pioneer Venus Probes	49
RALPH KAHN. Deducing the Age of the Dense Venus Atmosphere	71
G. W. BRASS AND C. G. A. HARRISON. On the Possibility of Plate Tectonics on Venus.....	86
RAYMOND F. JURGENS. Radar Backscattering from a Rough Rotating Triaxial Ellipsoid with Applications of the Geodesy of Small Asteroids	97
JONATHAN GRADIE AND JOSEPH VEVERKA. When Are Spectral Reflectance Curves Comparable?	109
MICHEL BREGER AND WILLIAM D. COCHRAN. Polarimetry of Pluto.....	120
C. D. MURRAY. Nodal Regression of the Quadrantid Meteor Stream: An Analytic Approach	125
JACK D. DRUMMOND. Theoretical Twin Meteor Showers	135
JACK D. DRUMMOND. Theoretical Meteor Radiants of Apollo, Amor, and Aten Asteroids	143
BOOK REVIEWS	
V. V. RADZIEWSKI. <i>Solid Particles in the Solar System</i> . Edited by Ian Halliday and Bruce A. MacIntosh.....	154
STUART J. WEIDENSCHILLING. <i>Early Solar System Processes and the Present Solar System</i> . Edited by D. Lal	155
STANLEY F. DERMOTT. <i>Interiors of the Planets</i> . By A. H. Cook.....	156
SEAN C. SOLOMON. <i>Geophysics of Mars</i> . By R. A. Wells	157
ALAN HARRIS. <i>Computational Spherical Astronomy</i> . By Laurence G. Taff ...	158

NUMBER 2, FEBRUARY 1982

ESSAM A. MAROUF, G. LEONARD TYLER, AND VON R. ESHLEMAN, Theory of Radio Occultation by Saturn's Rings	161
AUDOUIN DOLLFUS AND SERGE BRUNIER., Observation and Photometry of an Outer Ring of Saturn	194
R. R. DANIEL, S. K. GHOSH, K. V. K. IYENGAR, T. N. RENGARAJAN, S. N. TANDON, AND R. P. VERMA. Far-Infrared Brightness Temperature of Saturn's Disk and Rings	205

S. T. MASSIE AND D. M. HUNTEN. Conversion of <i>para</i> and <i>ortho</i> Hydrogen in the Jovian Planets	213
H. H. AUMANN, J. V. MARTONCHIK, AND G. S. ORTON. Airborne Spectroscopy and Spacecraft Radiometry of Venus in the Far Infrared	227
ROGER N. CLARK. Implications of Using Broadband photometry for Compositional Remote Sensing of Icy Objects	244
RICHARD A. SIMPSON, G. LEONARD TYLER, JOHN K. HARMON, AND ALAN R. PETERFREUND. Radar Measurement of Small-Scale Surface Texture: Syrtis Major	258
V. S. SAFRONOV AND E. L. RUSKOL. On the Origin and Initial Temperature of Jupiter and Saturn	284

NUMBER 3, MARCH 1982

OBITUARY. Seymour L. Hess	297
A. G. W. CAMERON, WILLIAM M. DECAMPLI, AND PETER BODENHEIMER. Evolution of Giant Gaseous Protoplanets Embedded in the Primitive Solar Nebula ..	298
M. TORBETT, R. GREENBERG, AND R. SMOLUCHOWSKI. Orbital Resonances and Planetary Formation Sites	313
CHARLES F. YODER. Tidal Rigidity of Phobos	327
FRANCOIS MIGNARD. Radiation Pressure and Dust Particle Dynamics	347
STEVEN J. OSTRO, GORDON H. PETTENGILL, DONALD B. CAMPBELL, AND RICHARD M. GOLDSTEIN. Delay-Doppler Radar Observations of Saturn's Rings	367
L. A. LEBOSKY, M. A. FEIERBERG, AND A. T. TOKUNAGA. Infrared Observations of the Dark Side of Iapetus	382
W. T. THOMPSON AND D. VAN BLERKOM. A Monte Carlo Approach to Scattering off Surfaces of Triaxial Ellipsoids	387
THOMAS E. THORPE. Martian Surface Properties Indicated by the Opposition Effect ..	398
P. DROSSART, T. ENCRENAZ, V. KUNDE, R. HANEL, AND M. COMBES. An Estimate of the PH ₃ , CH ₃ D, and GeH ₄ Abundances on Jupiter from the Voyager IRIS Data at 4.5 μ m	416
JEROME APT AND JOHNNY LEUNG. Thermal Periodicities in the Venus Atmosphere ..	427

BOOK REVIEWS

A. H. DELSEMME. <i>Introduction to Comets</i> . By John C. Brandt and Robert D. Chapman	438
J. VEVERKA. <i>Earthlike Planets (Surfaces of Mercury, Venus, Earth, Moon, and Mars)</i> . By Bruce Murray, Michael C. Malin, and Ronald Greeley	439

AUTHOR INDEX FOR VOLUME 49	440
----------------------------------	-----

The Subject Index for Volume 49 will appear in the December 1982 issue as part of a cumulative index for the year 1982.

ICARUS is devoted to the publication of original contributors in the field of solar system studies. Manuscripts reporting the results of new research—observational, experimental, or theoretical—concerning the astronomy, geology, meteorology, physics, chemistry, biology, and other scientific aspects of the solar or extrasolar systems are welcome. The journal generally does not publish papers devoted *exclusively* to the Sun, the Earth, celestial mechanics, or astrophysics. The preferred language of publication is English, but in special cases manuscripts are considered in French, German, or Russian. All papers are reviewed, generally by two independent referees. If authors so request in their cover letters, manuscripts will be handled anonymously during the refereeing process. Authors may be asked to respond to criticisms and suggestions by the referees prior to publication.

Manuscripts are accepted for review with the understanding that the same work has not been and will not be published, nor is presently submitted elsewhere, and that all persons listed as authors have given their approval for the submission of the paper; further, that any person cited as a source of personal communication has approved such citation. Written authorization may be required at the Editor's discretion. Articles and any other material published in *Icarus* represent the opinions of the authors and should not be construed to reflect the opinions of the Editors or the Publisher.

Authors submitting a manuscript do so on the understanding that if it is accepted for publication, copyright in the article, including the right to reproduce the article in all forms and media, shall be assigned exclusively to the Publisher. The Publisher will not refuse any reasonable request by the author for permission to reproduce any of his or her contributions to the journal.

There are no page charges. However, authors will be charged for color reproduction; the publisher will provide an estimate of cost on request. Fifty *reprints* of each paper will be furnished gratis to the author and additional reprints may be purchased.

Manuscripts. Four copies of the manuscript, including figures, tables, etc., should be submitted to Dr. Joseph A. Burns, Space Sciences Building, Cornell University, Ithaca, New York 14853, telephone: 607-256-4875. Authors should retain the original typescript. One of the four sets of figures should be suitable for camera-ready reproduction. All manuscripts must be typewritten with wide margins and **double-spaced throughout**, including references and footnotes. Number each page of the manuscript. Include on the first page the title and name(s) and affiliation(s) of all author(s), including mailing address(es). At the bottom of this page note the number of manuscript pages, figures, and tables. On the second page indicate a proposed running head of not more than 35 characters, and the name and address to which editorial correspondence and proofs should be directed. The third page should contain a brief abstract, and the text should begin on the following page. Following the main text, give Appendixes, Acknowledgments, references, tables, figure captions, and figures, in that order. Places where figures and tables are to appear in the published paper should be marked in the margins of the manuscript.

Tables are to be numbered consecutively with Roman numerals in order of their citation in the text. Each table should be typed, **double-spaced**, on a separate sheet with due regard to the proportions of the printed page. All tables should bear appropriate headings. Unusually elaborate tables should be prepared to allow them to be reproduced in the journal directly without typesetting.

Figures. At the time of submission of the manuscript, one original of each figure is to be submitted in such form as to permit photographic reproduction without redrawing: Line drawings should be carefully drafted, no larger than 22 × 30 cm. Both original drawings or standard glossy photographic reproductions are acceptable. The lettering should be large enough to allow a reduction to $\frac{1}{4}$ the original size. **Each figure should be identified with the author's name and figure number.** All figures, whether line drawings or halftones, should be numbered consecutively in Arabic numerals, in order of their citation in the text. Figure captions should be typewritten on a separate sheet, following the text. Color plates and foldouts are published at the author's expense.

Literature citations in the text should be in one of the following forms: Morrison and Cruikshank, 1974 (for two authors); Marov *et al.*, 1980 (for three or more authors); Walker, 1977, p. 198 (for reference to a specific page). To distinguish two or more works by the same author(s) in the same year, use suffixes a, b, etc., following the year (e.g., Öpik, 1976a, 1976b).

Literature citations in the bibliography should be **listed alphabetically** according to the surname of the (first) author. Journal references should contain the **names and initials of all authors, the year, the title of the article, the standard abbreviation of the journal, the volume number, and the first and last page numbers.** Titles of journals and books should be in italics, volume numbers in boldface. (In a typed manuscript, indicate italics by single underlining and boldface by wavy underlining.) Below are shown examples of the proper reference forms for a journal article, a book chapter, and a book, respectively.

PEALE, S. J., P. CASSEN, AND R. T. REYNOLDS (1979). Melting of Io by tidal dissipation. *Science* **203**, 892–894.

WHIPPLE, F. L. (1981). *Orbiting the Sun*. Harvard Univ. Press, Cambridge, Mass.

ZHARKOV, V. N., AND V. P. TRUBITSYN (1976). Structure, composition and gravitational field of Jupiter. In *Jupiter* (T. Gehrels, Ed.), pp. 133–175. Univ. of Arizona Press, Tucson.

Careful compliance with these instructions for the preparation of the list of references is required; manuscripts with incomplete references (or missing abstracts) may be returned to the author for correction before being considered for publication.

Guidelines for Submission of "Notes": Papers on especially topical subjects will be given unusually rapid handling if they satisfy the following limitations on length:

(i) Manuscripts should be typed double-spaced and should be no longer than nine pages, including a very brief abstract of one or two sentences.

(ii) The sum of figures and tables should be less than, or equal to, two.

We expect that ICARUS will publish "Notes" within four months of submission, if no revision is required. We will try to complete refereeing and editorial handling in less than one month. In order to accelerate publication, proofs of "Notes" will be proofread only at Academic Press.

Please write with attention to organization, style, and especially brevity. Present results logically, with order dictated by the needs of the reader. Take special care in composing the title and abstract, since these will be the most frequently read sections of the paper. In the title, specific words are preferable to general ones. The abstract should summarize the conclusions of the research, including quantitative results where appropriate, rather than merely stating the problem.

Whenever possible, quotients in mathematical expressions should employ the solidus (/) rather than being displayed in built-up form. However, for units, exponential notation is preferred (e.g., $\text{erg cm}^{-2} \text{s}^{-1}$, not $\text{erg/cm}^2 \text{s}$). Most authors will recall the difference between "i.e." and "e.g.," will note that such nouns as "data" are plural and "mare" singular, and will take care to insert a zero before decimal fractions lying between +1 and -1.

Proofs will be sent to authors. When submitting a manuscript, the author should include a list of the symbols employed, identified typographically, not mathematically. This list will not be printed, but will help to avoid costly author's corrections in proof. Authors will be charged for excessive alterations in proof.